SINDH IRRIGATION AND DRAINAGE AUTHORITY

SINDH WATER SECTOR IMPROVEMENT PROJECT-I (WSIP-I)

PREPARATION OF REGIONAL PLAN FOR THE LEFT BANK INDUS, DELTA AND COASTAL ZONE

Bio-Saline Agriculture in Badin and Thatta Districts

Feasibility Study

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In Association with
Indus Associated Consultants
December, 2012

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Acronyms

EC_w	Electrical conductivity of water
EC_e	Electrical conductivity of soil extract
SAR	Sodium absorption ratio
RSC	Residual Sodium Concentration
Glycophytes	Salt tolerant crops
SIDA	Sindh Irrigation and Drainage Authority
PID	Provincial Irrigation Department
NGO	Non Government Organization
EIRR	Economic Internal Rate of Return
LBOD	Left Bank Outfall Drain
KPOD	Kadhan Pateji Outfall Drain
TDS	Total dissolved solids
dS/m	Desi Siemen per meter
PKR	Pakistan Rupees
m	meter

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Executive Summary

Background and Rationale

In Sindh, fresh water resources both for domestic and agricultural use are constantly depleting and crop yields suffer from a steady increase in soil salinity, especially in the arid and semi-arid areas. Equally or even more affected in some cases, are other resources like fodder for animals and fuel wood for the rural poor. Efforts are hence needed to find an alternate source of water and utilization of saline lands for economic benefits. Increasing need for food, fuel and forage for the growing human and animal population, has exerted a lot of pressure on these resources.

Under the bio-saline approach, useful production can be achieved from salt-affected wasteland without reclamation. The main focus is on the economic utilization of the land while still in the saline or sodic condition. There may be improvements in soil condition but this is a spin-off benefit. The latest promising bio-saline approach involves re-vegetation of salt-affected lands using salt-tolerant crops, trees, grasses and salt bushes. Growing salt-tolerant crops increases food and fiber, salt-tolerant grasses can help improve the grazing for animals. Similarly, growing trees and saltbushes has the added bonus that helps fill local needs for forage and fuel wood. The most common fuel is dried animal dung but provision of alternative fuels would enable this to be returned to the fields to improve the fertility of the land.

Research on reclamation of salt-affected soils, utilization of wastelands for cropping of suitable species, and fish culture, use of saline water for irrigation purpose etc. has been underway for quite some time by various institutions throughout the country. In Sindh, various public and private organizations are actively involved in education, research and development bio-saline agriculture interventions. A number of technology options have been determined and tested from time to time for different situations. It is high time that integrated approach is made to implement the available technology to the benefit of farming community, to alleviate poverty in the rural masses, and to improve the environment. Farmer participation in these programs is key factor in the success of these interventions.

The drainage of effluent Kotri command area is carried through 18 major drainage systems. These drainage systems are carrying drainage effluent into sea except for three drains which are out falling into river Indus. One of these drainage systems Kadhan Pateji Outfall Drain (KPOD) is connected to LBOD and Tidal Link for outfall into Sea. The total design discharge capacity of the whole system on left bank is about 8,050 cusecs. The salinity level of the drainage effluent is about 2 dS/m which is suitable to grow most crops on marginal lands.

The drainage effluent if used for bio-saline agriculture would supplement farm incomes and would release pressure on the main drainage system. Evidence from Pakistan and elsewhere show that the salt tolerant crops (glycophytes) irrigated with the brackish water grown on marginal lands have shown promise. These crops include salt tolerant varieties of wheat, barley, oilseeds, cotton, and different vegetables.

The communities in the coastal area, particularly in the Badin district proposed that since their natural resource base has degraded, hence technical support is needed to increase their farm productivity. It was suggested that if they are given access to the drainage water through public lift pumps, they would be able to grow salt tolerant crops. In response to this, the Consultants a Pre-feasibility was prepared to support and introduce bio-saline agriculture along the drainage network and the same was discussed with the stakeholders during the Phase-II of the study.

Issues and Problems

There are several strategies involved in the management of the saline soils like engineering approach, reclamation approach and Bio-saline agriculture approach. Engineering approach required draining the brackish water from soil and underground. Various drainage projects like SCARPs, Tile drainage projects and tube wells were used to reclaim the land affected by water logging and salinity but the efforts could not yield anticipated results. It is estimated that over 100 hectares of land is becoming saline every day. This situation is very alarming and particularly in Sindh province, because lands are becoming saline more in Sindh than the other provinces. The climate of Sindh is arid and hot. On an average, the region receives the maximum rainfall of 170-200 mm. Because of shortage of irrigation water, the biological approach for reclaiming the saline and water logged soils through leaching is handicapped. The only option left to use such lands for crop production is through bio-saline agriculture.

Scientists are conducting experiments utilizing seawater for agriculture particularly in sandy soils. Sand is inherently low in the nutrients required for plant growth, has a high rate of water infiltration, and has low water-holding capacity. Therefore, agriculture on sand requires both irrigation and fertilizer. Surprisingly, 11 of the 13 mineral nutrients needed by plants are present in seawater in adequate concentrations for growing crops. In addition, the rapid infiltration of water through sand reduces salt buildup in the root zone when seawater or brackish water is used for irrigation. The high aeration quality of sand is also valuable. This characteristic allows oxygen to reach the plant roots and facilitates growth. Thus the combination of sand, saltwater, sun, and salt-tolerant plants present a valuable opportunity for many developing countries. Brackish water with comparatively less salinity than seawater is best to be use in sandy soils with success.

Water scarcity coupled with marginal soil and water resources warrant the use of bio-saline agriculture to get appreciable production from presently unproductive lands lying barren for want of fresh water. At present the drains of some areas are polluted with sugar mill effluent. Efforts shall however, be focused to stop the sugar mills effluent entering in the drainage system, because the users will hesitate using the sugar mill effluent laden waters in their lands for agriculture.

Project Location

There exist vast areas under marginal lands in Badin and Thatta districts. Under water scarcity conditions these areas are left barren without any vegetation. In Pinyari command, 65% of the soils are saline, while in Lined channel and Phuleli command, about 50% soils are either moderately or highly saline. The drainage water of surface drains of Kotri surface drainage system is marginal water with TDS below 2000 ppm that may beneficially be utilized for bio-saline agriculture for growing salt tolerant crops, shrubs, trees and grasses.

Objectives

Main objectives of the proposed project are to i) Reduce the area of culturable waste ii) minimize the degradation and desertification of lands iii) offload the pressure on the main drainage system iv) improve environment of the area and v) to improve socio-economic conditions of the communities

Due Diligence

Due to scarcity of fresh water resources all over the world and especially in the developing countries, efforts are underway to utilize brackish water and saline lands for growing salt tolerant crops, grasses, trees and shrubs. Having a very limited knowledge of utilization of brackish water for crop growing, people normally leave their marginal lands barren without any crop or vegetation. This renders the lands totally un-useable for farming. There is plenty of brackish water with permissible salinity levels suitable for growing a number of crops, fruit trees, grasses and fuel wood trees. This is the best opportunity to bring the marginal lands under cultivation to support the poor people to earn their livelihood and rear livestock on the grasses grown on marginal lands. Crops that can better be grown in saline lands are barley, cotton, sorghum, durum wheat, soyabean, groundnuts, rice, sugarcane and maize.

Outcome and Impact

As a pilot project, selected salt tolerant crops, grasses, and trees will be grown on about 50,000 acres, generating an estimated annual net farm income of Rs.3000 per acre per year. This will not only increase the farming intensity, will also enhance the household income of participating farmers, and will also provide additional employment to landless labor. The proposed project will also have several indirect benefits, such as increased availability of better nutrition to household members, will also help in the availability of fodder and forage for the livestock, and would arrest further degradation of soils. The project will reduce pressure on overall drainage system thereby eliminating the risk of breaches, overtopping and back flow in the branch and sub-drains, The intervention will increase overall agriculture produce, sustain the livestock and better utilize the wastewater which otherwise will flow into the sea through drainage.

Implementation arrangements

Since the drains are flowing below the ground level the water at suitable points will be pumped into purpose built channels along the drains. All the operations of the project will be executed through participatory approach. The SIDA/PID will procure and install the lift pumps, and the community groups will operate and maintain the lift pumps. An NGO will be engaged for community mobilization. The agriculture department will provide support for soil testing and identification of appropriate crops and varieties.

Monitoring Framework

Project manager with supporting staff will monitor the activities of the project in accordance with the designed work plan. *Warabandi* of the turn of water will be based on the land holdings and the availability of the water. Selection of the crops, trees, grasses will be on the bases of type of the soil, extent of salinity of the holding and on scientific grounds on recommendations of the project management. Code of conduct shall be framed out in consultation with stakeholders with mutual agreement of all the partners. Conflict resolution committee comprising of the project management and notables shall resolve the conflicts amicably.

Project Cost

The total cost of intervention is estimated as Rs.1.038 billion. This includes cost of procurement and installation of lift pumps at Rs.50,000 each, cost of laying out distribution system, land clearance and cost of Management and Community Mobilization through NGO.

Economic Viability

The preliminary analysis suggests an indicative EIRR of 14.3 percent. Nonetheless, the project has been designed based on the assumption that the hazardous sugar mills effluent discharged into selected drains is completely terminated, else the drain water will not be usable for bio-saline agriculture, and farmers will be reluctant to use this water.

Environmental Safeguards

The proposed project is environment friendly as it will not have any adverse impacts on any green infrastructure of the areas. Any salinity build up in the marginal soils due to application of the saline drainage water would be washed off with the rain water flows in monsoons. Moreover, only those crops, grasses, and trees will be selected that will help reduce the soil salinity. This intervention will improve the ecosystem and local environment; reduce desertification, encourage livestock production as well as agriculture produce and thus make the life of the communities a bit comfortable.

Social safeguards

The proposed project will increase the productivity of the degraded lands thereby improving the economic status of the farming community. In addition it will provide livelihood opportunities through employment generation and alleviate poverty.

Bio-saline Agriculture in Badin and Thatta Districts

1 Introduction

In Sindh, fresh water resources both for domestic and agricultural use are constantly depleting and crop yields suffer from a steady increase in soil salinity, especially in the arid and semi-arid areas. Equally or even more affected in some cases, are other resources like fodder for animals and fuel wood for the rural poor. Efforts are hence needed to find an alternate source of water and utilization of saline lands for economic benefits. Increasing need for food, fuel and forage for the growing human and animal population, has put a lot of pressure on these resources. One of the approaches to utilize such lands and water is the bio-saline agriculture under which crops are grown by utilizing saline water

Under the bio-saline approach, useful production can be achieved from salt-affected wasteland without reclamation. The main focus is on the economic utilization of the land while still in the saline or sodic condition. There may be improvements in soil condition but this is a spin-off benefit. The latest promising bio-saline approach involves re-vegetation of salt-affected lands using salt-tolerant crops, trees, grasses and salt bushes. Growing salt-tolerant crops increases food and fiber, salt-tolerant grasses can help improve the grazing for animals. Similarly, growing trees and saltbushes has the added bonus that helps fill local needs for forage and fuel wood. The most common fuel is dried animal dung but provision of alternative fuels would enable this to be returned to the fields to improve the fertility of the land.

Research on reclamation of salt-affected soils, utilization of wastelands for cropping of suitable species, and fish culture, use of saline water for irrigation purpose etc. has been underway for quite some time by various institutions throughout the country. In Sindh, many public and private sector organizations are actively involved in bio-saline agriculture interventions. A number of technology options have been determined and tested from time to time for different situations. It is high time that integrated approach is made to implement the available technology to the benefit of farming community, to alleviate poverty in the rural masses, and to improve the environment. Farmer participation in these programs is key factor in the success of these interventions.

The drainage of effluent Kotri command area is carried through 18 major drainage systems. These drainage systems are carrying drainage effluent into sea except for three drains which are out falling into river Indus. One of these drainage systems Kadhan Pateji Outfall Drain (KPOD) is connected to LBOD and Tidal Link for outfall into Sea. The total design discharge capacity of the whole system on left bank is about 8,050 cusecs. The salinity level of the drainage effluent is about 2 dS/m which is suitable to grow most crops on marginal lands.

The drainage effluent if used for bio saline agriculture, would supplement farm incomes, and would release pressure on the main drainage system. Evidence from Pakistan and elsewhere show that the salt tolerant crops (glycophytes) irrigated with the brackish water grown on marginal lands has shown promise. These crops include salt tolerant varieties of wheat, barley, oilseeds, cotton, and different vegetables.

The communities in the coastal area, particularly in the Badin district reported that since their natural resource base has degraded, support is needed to increase their farm productivity. It was suggested that if they are given access to the drainage water through public lift pumps, they would be able to grow salt tolerant crops. In response to this, the Consultants prepared this feasibility study to support and introduce bio-saline agriculture along the drainage network.

1.1 Problem Statement

There are several strategies involved in the management of the saline soils like engineering approach, reclamation approach and Bio-saline agriculture approach. Engineering approach required draining the brackish water from soil and underground. Various drainage projects like SCARPs, Tile drainage projects and tube wells were used to reclaim the land affected by water logging and salinity but the efforts could not yield anticipated results. It is estimated that over 100 hectares of land is becoming saline every day (Alam and Ansari 2000) . This situation is very alarming and particularly in Sindh province, because lands are becoming saline more in Sindh than the other provinces. The climate of Sindh is arid and hot. On an average, the region receives the maximum rainfall of 170-200 mm. Because of shortage of irrigation water, the biological approach for reclaiming the saline and water logged soils through leaching is handicapped. The only option left to use such lands for crop production is through bio-saline agriculture.

Scientists are conducting experiments utilizing seawater for agriculture particularly in sandy soils. Sand is inherently low in the nutrients required for plant growth, has a high rate of water infiltration, and has low water-holding capacity. Therefore, agriculture on sand requires both irrigation and fertilizer. Surprisingly, 11 of the 13 mineral nutrients needed by plants are present in seawater in adequate concentrations for growing crops. In addition, the rapid infiltration of water through sand reduces salt buildup in the root zone when seawater or brackish water is used for irrigation. The high aeration quality of sand is also valuable. This characteristic allows oxygen to reach the plant roots and facilitates growth. Thus the combination of sand, saltwater, sun, and salt-tolerant plants present a valuable opportunity for many developing countries. Brackish water with comparatively less salinity than seawater is best to be use in sandy soils with success.

Since last 20 years, commendable research on using brackish water on marginal lands has been carried out and there are many success stories in this respect on growing suitable crops, grasses, saltbushes, fruit and other trees in various areas of the country with great success. Saline areas can be made productive through bio-saline agriculture or growing halophytes. These are plants which are capable of making good growth in degraded waste lands due to salinity. There are various kinds and species of halophytes acceptable to saline and waterlogged environment having specialized and distinguished environmental characteristics. The species range from grasses and shrubs to trees occurring in diversified environment such as coastal swamps, marshes, saline and waterlogged areas. Some halophytes possess special characteristics and habitats. Some herbs, shrubs and trees extract salt from soil to reclaim the land and produce important bio-mass.

Water scarcity coupled with marginal soil and water resources warrant the use of bio-saline agriculture to get appreciable production from presently unproductive lands lying barren for want of fresh water. At present the drains of some areas are polluted with sugar mill effluent. Efforts shall however, be focused to stop the sugar mills effluent entering in the drainage system, because the users will hesitate using the sugar mill effluent laden waters in their lands for agriculture.

1.2 Project Location and boundaries

The proposed project is located in Badin and Thatta districts and covers the entire Kotri barrage command area. The surface drains of the area mostly contain the brackish water with 1000-2000 ppm salinity. This water can be effectively used on marginal lands to grow salt tolerant species of crops, trees and grasses. In some areas of Badin district where the drain water is not polluted with sugar mill effluents; some farmers are found practicing the bio-saline agriculture successfully and getting substantial production from their marginal lands.

The proposed project will be executed in the command area of the Pinyari, Phuleli and Akram Wah in Thatta and Badin Districts. The area under marginal lands in Badin and Thatta districts are marked with red border on the map in Figure-1. These areas are either moderately or highly saline spread on thousands of acres. Under water scarcity conditions these areas are left barren without any vegetation. In Pinyari command, 65% of the soils are saline, while in Lined channel and Phuleli command, about 50% soils are either moderately or highly saline Table-1.

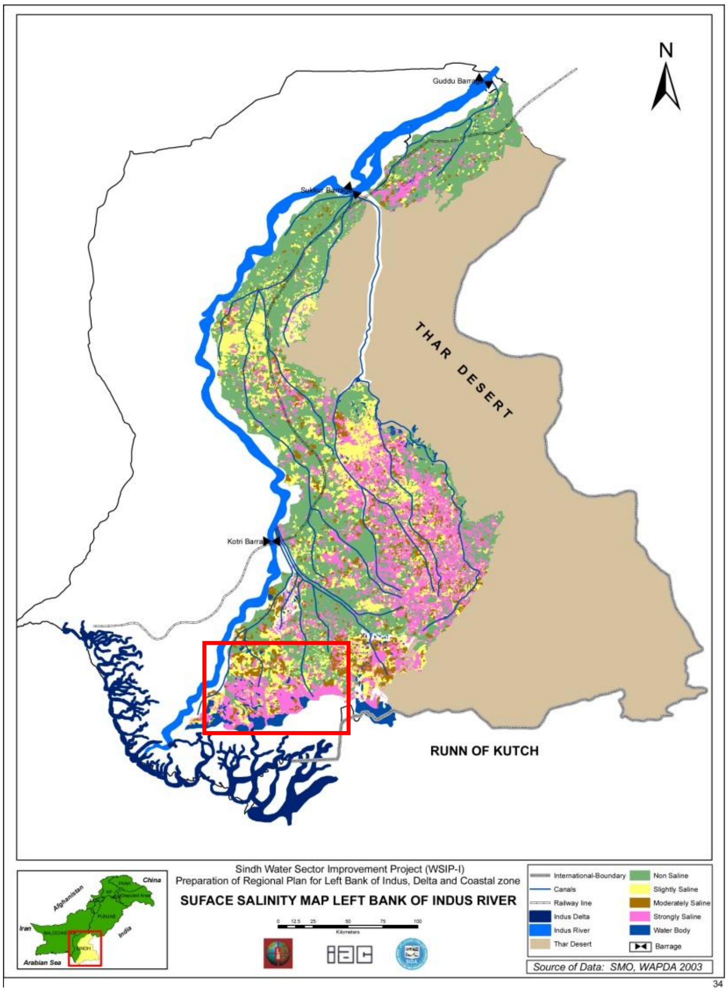

Figure 1: Highly Saline area of Thatta and Badin

Table 1: Command Wise Salinity Status of the Area

Sr.#	Main Canals	Area in acres	Non-Saline EC_e=0-4	Slightly Saline EC_e=4-8	Moderately Saline EC_e = 8-15	Strongly Saline EC_e>15	Miscellaneous area	Total
	Pinyari	981207	22	19	5.0	40	14	100
	Fuleli	1045651	44	21	10	20	5.0	100
	Lined Channel Akram Wah	531965	27	23	15	22	13	100

2 Kotri Surface Drainage System

The drainage of Kotri command area is carried through 15 major drainage systems. These drainage systems are carrying drainage effluent into sea except for three drains which are out falling into river Indus. One of these drainage systems Kadhan Pateji Outfall Drain (KPOD) is connected to LBOD and Tidal Link for outfall into Sea. The total design discharge capacity of the whole system is about 8049 cusecs. The total discharge into river as estimated from design discharge capacity of drains out falling into river comes to about 130 cusecs (i.e. 1.6% of total design discharge capacity of system). The water of the drains has salinity of about 2 dS/m which is suitable to grow most crops on marginal lands. Other than the LBOD surface drain infrastructure, the Kotri drainage system comprises of:

2.1 Nagan Dhoro Outfall Drainage System

Nagan Dhoro outfall Drainage System lies in the command area of Pinyari Canal on the Left Bank of River Indus. The drainage affluent generated from Catchment area collected from network of drains ultimately outfalls in the Arabian Sea through Kala Channi Dhand. The drainage system provides drainage facilities including removal of pancho water from irrigated lands and storm water. Nagan Dhoro outfall Drainage system provides drainage facility to Gross area of 0.332 m acres.

2.2 Karo Ghungro Outfall Drainage System

Karo Ghungro Surface Drainage System is located in Districts Tando Muhammad Khan and Badin. Drainage System was constructed in the sixties. It serves removal of surface runoff from the catchment area of Fuleli Canal on the Left Bank of River Indus. The Gross command area of the System is 0.295 m acres.

2.3 Fuleli Guni Outfall Drainage System

Construction of Fuleli Guni outfall Drainage System was started in 1959 and completed in 1960. Drainage System is situated within command area of Fuleli Canal. The drainage System provide drainage facility for evacuating pancho water from rice fields and storm Water through network of drain spread over the catchment area. Total length of Drains in the Fuleli Guni outfall Drainage System is 402.8 km including of Fuleli Guni outfall Drain (36.2) km. Fuleli Guni outfall drain including complete drainage system has been rehabilitated under. National Drainage Program in 2003-04 and System has been restored to its original design.

Instead of wasting this water resource draining into the sea, it can be utilized on marginal lands for bio-saline agriculture. Experiments within country and abroad on salt tolerance of various crops indicated that a number of crops can be grown on marginal lands using brackish water achieving appreciable yields. Salt-tolerant plants can utilize land and water unsuitable for salt-sensitive crops (glycophytes) for the economic production of food, fodder, fuel, and other products. Some types of wheat, barley, rice and cotton can also be grown in saline water or saline soil. Tomatoes, onions, and melons are grown commercially using underground brackish water for irrigation.

Lands left barren for long time become deserted and unsuitable for further cropping. Therefore, saline soils if used for growing salt tolerant crops using brackish water can be productive and remain receptive for different crops by the passage of time.

Table 2: Soil Salinity and Sodicity Classification

	Salinity		Sodicity	
	Salinity Class	EC_e or EC_s	Sodicity Class	SAR
1	Salt-free (non-saline)	<4	Non-Sodic	<13
2	Slightly Saline	4-8	Slightly Sodic	13-25
3	Moderately Saline	8-15	Moderately Sodic	25-45
4	Strongly Saline	>15	Strongly sodic	>45

Source: Qureshi and Lennard 1998

Table 3: Water Quality Classification based on (EC), (SAR) and (RSC)

Sr.#	Classification	EC (dS/m)	SAR	RSC
1	Useable $C_1S_1R_1$	<1.5 (C_1)	<10 (S_1)	<2.5 (R_1)
2	Marginal $C_2S_2R_2$	1.5-3.0 (C_2)	10-18 (S_2)	2.5-5.0 (R_2)
3	Hazardous $C_3S_3R_3$	>3 (C_3)	>18 (S_3)	>5 (R_3)

Source: Qureshi and Lennard 1998

3 Physiography and Topography

The project area is a part of lower Indus plain which was under sea at one time (SSR report Badin 1970) and was gradually filled up with tremendous amount of alluvium brought by the Indus River and its tributaries. Therefore, soils of this area can be divided into three major classes (land forms) (i) the river plain without having any effect of the sea, (ii) the estuary plain with depositions made under the sea influence (iii) the coastal belt flooded by sea.

Coastal areas have flat topography. There exists a very mild slope of 2-3 inches a mile. This favors the inland intrusion of sea at the rate of 2 km per century. Therefore, sea intrusion is a major problem of the area. The underground water of the entire district Badin and most parts of Thatta is mostly saline

4 Soils of the area

Soils of coastal areas are slight to moderately saline while some areas are highly saline. The most dominant textural groups (50%) are mainly sandy clay loam, clay loam and silty clay loam with loam, silt loam and silt in about 20% areas. The remaining portions are sandy loam and fine sandy loam soils. Generally the soils are hard and poorly drained in nature.

5 The River Plain

The northern part of Badin area is mostly occupied by the recent and sub recent, levees and channel infill's. At one time it was a deltaic head, but later on it was covered by the continuous depositions of soil material from the Indus River. The river shifted its course to the west and major deposition was stopped (Soil Survey Report 1970). Ever since then the southern boundary has remained unchanged. The soils at some places are slight to moderately saline, where as underground water is highly saline.

5.1 The Estuary Plain

The major part of area is covered by this plain; it has been formed by depositions made by river estuaries which were under the influence of the sea tides. The main deposits are silty with high proportion of silt & very fine sand. Sub recent spill flats, basins and channel infills are the main land form units.

5.2 The Coastal Belt

The coastal belt has remained the active part of the river delta in past and after the shifting of the river course; the plain was encroached upon the sea tides. It consists mainly of tidal flats, and some ridges in addition to tidal lakes, sea creeks and coastal playas. Most of tidal flats and basins are subject to frequent flooding by sea water.

5.3 Soil Textural classification

Texture being a more permanent characteristic of soil, is not expected to change within a short span of time. For classification and mapping purpose, the available latest data collected and reported by S&R SMO WAPDA in 2006, has been utilized and the criteria used for appraisal is the same as given in soil survey manual, agriculture handbook No. 18, therefore, on the basis of that textural groups and their corresponding five (05) soil series have been recognized and presented in a tabular form.

Table 4: Soil Textural Groups

S. No.	Textural Group	Soil Series	Component Textural Classes	Area in Acres	% of Area
1.	Coarse	Jhang	Sand, Loamy sand	33,477	8
2.	Moderately Coarse	Farida	Sandy Loam & fine Sandy loam	50,214	12
3.	Medium	Buchiana	Loam, silt loam and silt.	83,689	20
4.	Moderately Fine	Chuhar kana	Sandy clay loam, clay loam and silty clay loam	188,304	45
5.	Fine	Nokhar	Sandy clay, silty clay & clay	-	-
6.	*Miscellaneous:			62,767	15
Total				**418,451**	**100**

*Miscellaneous land type: This type of land comprises cities, Towns, villages, road, railways, canals, drains, industries and water bodies.

5.4 Land Use in the proposed project area

Badin area falls at the tail end of irrigation system. Major part of area is commanded by the canals of Kotri Barrage system, the left over un-commanded part is subject to the tidal effect/flooding by sea water and has no possibility of agriculture. The lands of this area are used in different ways and mainly depending upon the water supply and prevailing soil conditions. Some of the commanded area is also lying uncultivated due to strong salinity or sandy nature of the soils and could provide only poor grazing. Climate also plays the main role in land use of the area, being an arid and semi-arid, the cultivation is possible only with irrigation of one or the other kind. However, the crop production is possible both in summer & winter because of favorable temperatures for plant growth throughout the year. In southern parts the rice and sugar cane are the main crops in Kharif with introduction of sunflower especially in those areas, where there is a shortage of irrigation water. In northern parts of area cotton as cash crop is mostly cultivated on fertile and homogenous soils. In winter the vegetables of this area are famous, where as wheat and oil seeds are grown generally. Therefore, keeping under consideration the different factors, soils of the area are categorized as under and presented into tabular form.

Table 5: Extent of Land Use Classes (Project Area)

Ser No.	Type	Acres	Percent of area
1.	Perennially Canal Irrigated	264263	63
2.	Unproductive Land	87299	21
3.	Sand Dunes	2094	0.5
4.	Miscellaneous Land Type	64795	15.5
5.	Total	418451	100

Source: S&R project SMO WAPDA (2003)

5.5 Perennially Canal Irrigated

It is obvious from the table that the cultivated land occupies about 264263 acres (63%) of the area. Rice, sugar cane, cotton are the main crops in Kharif, where as wheat, oil seed, pluses and vegetables are grown in Rabi. Most of the area is under mechanized farming.

5.6 Presently Unproductive Lands

The unproductive land occupies 84299 acres (21%) of the area. Such type of soils are strongly saline and lying abandoned and only supports thin cover of salt tolerant natural vegetation.

5.7 Sand Dunes

The negligible area covering about 2094 (0.5%) acres has been identified under sand dunes. The smallest dunes have mostly been removed by the land owners, so that the area could be brought under cultivation.

5.8 Miscellaneous Land Type

This class includes towns villages, settlements, industries, road, railways canals and water bodies and covers an about 64795 areas (15.5%) of land.

6 Climate of the project area

Badin area including coastal and delta zone generally falls within the sub-region of lower Sindh. According to the climatic conditions, the area is categorized as tropical arid marine with typical character sties of moderate temperatures, low to moderate rain fall. The inflow of sea breeze is throughout the summer and has a remarkable influence on cultural landscape, having wind sails on the roof to catch the breeze. May and June are the hottest months with mean maximum temperature of 41° to 43°Celsius (106-110^{o}F). By the end of June, monsoon season starts and remains up to August, but the rain fall remains within the range of 175 mm to 200 mm (7-8 inches) and sometimes heavy rain storm with cyclone in coastal and delta area arise from south-east and hit badly the nearest bordering area to sea. Some time an amount equivalent to the mean annual total rain falls in a single day, causing heavy loss to human life, livestock and infra structures. During winter the coldest months are December and January with mean minimum temperature 8 to 9^{O} Celsius (46^{O} to 47^{O}F) mostly the area is frost free. Evaporation rate is about 1675 mm (67 inches) in the area and the mean annual humidity is about 50 – 60 percent (Ref: MDP).

7 Socio-economic scenario

The project area is predominantly an agricultural area where variety of food, fodder, fruit, oilseed and cash crops are grown. Also trees are also the important component of the area grown in the form of agro-forestry. The economy and livelihood of the people of the area is dependent on agriculture and fisheries. This area is thickly populated having density ranging between 300-500 people per sq. km. There is about 21% land area that is mostly saline. This land is most suitable for bio-saline agriculture. The Nuclear institute of Agriculture is running a project on bio-saline agriculture but it is on experimental basis. The soils which are saline and non-productive can be brought under cultivation using the bio-saline agriculture technology where salt tolerant crops, grasses and halophytes can be grown with success. This will improve the socio-economic conditions of the local farming community on one hand and will help increase the agricultural production on the other.

8 Description of the Project

Vast areas in coastal belt are uncultivated due to scarcity of irrigation water and saline underground water. The surface drains carry *pancho* water from rice fields and storm water in monsoon season. The quality of drainage effluent is marginally saline with TDS in the range from 1000 ppm to 2000 ppm. This water is suitable for bio-saline agriculture. Thus soils lying uncultivated for the want of water can be brought under cultivation using drainage effluent of surface drains which is being drained into the sea via LBOD drainage infrastructure.

8.1 Project Type

The proposed intervention is non-structural. No any structure is proposed in this intervention. Option pertains to use of drainage water and storm water for growing salt tolerant crops, grasses, fruit and other trees and halophytes. This will bring the unproductive land into production with suitable crops, grasses for animals and wood trees that can sustain salinity of the soil and or water. This will certainly add to the income of the farmers and will improve the environment, improve the quality of the land and minimize the effect of land degradation.

8.2 Project Scope

As stated above, more than 700 cusecs of water with very marginal salinity is being drained into sea through KPOD. This valuable resource will help increase the production potential of marginal lands and will enhance the socio-economic wellbeing of the farming community. On the other hand, the pressure on the outfall system will also be reduced. Many areas in Thatta and Badin districts are lying out of cultivation for the want of water. Taking an average of 200 acres of land for 1 cusec of water, and assuming the drains to run at 50% capacity, the available water resource would be able to serve 70,000 acres in districts Thatta and Badin.

Keeping the lands under crop / vegetation will improve soil physical environment, overcome land degradation, reduce wind erosion, improve biodiversity and increase farmer’s income. .

8.3 Objectives of Project

1. To bring saline and sodic unproductive and uncultivated soils into production
2. To utilize marginal but useable water of the surface drainage system of Kotri barrage for production of salt tolerant crops, fruit and other wood trees, grasses and oil seed crops
3. To convert barren lands never cultivated in the past to productive lands to avoid desertification that is extending at an alarming rate in the coastal areas for want of water.
4. To help uplift the socio-economic conditions of the poor families who cannot bring their lands to production for want of suitable water for irrigation
5. The poor people cannot afford rearing the livestock due to scarcity of fodder from their poor quality lands
6. All such areas with marginal lands and water give a decertified look and such lands keep eroding when high speed winds carry away the top soil with it.
7. When people do not earn anything from such lands, they tend to migrate leaving the area barren and put pressure on other productive lands in other localities causing population density and overcrowding of the population

8.4 Approach and Methodology

Approach and methodology of the intervention is described in the following paragraphs:

8.5 Approach

Since the drains are flowing below the ground level therefore gravity flow of the water to the lands utilized for bio-saline agriculture shall not be possible. Therefore, the water at suitable points will be pumped to the desired area along the drain. This will be a participatory approach where the machinery will be provided by the government while the water courses will be excavated by the farmers themselves. The POL for the pumps will also be paid by the farmers.

With these incentives the farmers will be tempted to utilize the facility for their own benefit.

8.6 Methodology

All the operations of the project will be executed through participatory approach. The stakeholders including concerned Government Organizations, NGOs and local communities will be taken on board. They will be mobilized, organized and trained to plan, execute and maintain the project through an agreed mechanism of input and output sharing.

8.7 Stakeholder Involvement

Stakeholder's participation is of prime value for the success of any intervention focused to support the communities. In this project the basic role is to be played by the farmers themselves with support from line agencies, NGOs, and neighbouring farmers. Project staff shall guide the farmers in selection of suitable crop depending upon the salinity of the soil and water in use. The soil will be tested periodically for the salinity level to ensure that the farmer gets economic benefit without compromise on the status of his land resource. Conjunctive use of freshwater with saline water will be preferred if available so that the salinity should remain within safe limits. Farmers willing to opt for this intervention shall b e provided with the mobile pumps for pumping water from the drains to their lands for irrigating their crops, grasses and trees. They will pay the running costs of the machines including the repairs and maintenance. They will pay the cost of machine in 10 easy installments payable in the end of Kharif season.

8.8 Production from marginal soils

Occurrence of soil salinity problem in the irrigated areas of the Indus plain is one of the major threats to agriculture. The present estimates are that nearly 6.3 million hectares of area is in its grip. It limits crops production. Standard approach to reclaim a saline land is to install a drainage system, apply suitable amendment and purge the salts out of the soil by applying fresh water. This method has proved to be highly expensive and involves a high level of understanding of soil chemistry and engineering options. Saline areas can be made productive through bio-saline agriculture or growing halophytes. These are plants which are capable of making good growth in degraded waste lands due to salinity. There are various kinds and species of halophytes acceptable to saline and waterlogged environment having specialized and distinguished environmental characteristics. The species range from grasses and shrubs to trees occurring in diversified environment such as coastal swamps, marshes, saline and waterlogged areas. Most suitable crops, grasses, fruit and wood trees suitable for marginal land and water under bio-saline agriculture are listed in Tables 8, 9, 10 and 11. Some halophytes possess special characteristics and habitats. An adult tree is reported to utilize 235 to 2300 mm water annually and thus acts like a pump and controls water table naturally. Some crops, herbs, shrubs and trees extract salt from soil to reclaim the land and produce important bio-mass.

8.9 Benefits of intervention

Following benefits will be accrued;

1. Decreasing effluent load on the drainage system
2. Livelihood opportunities and farmer's income will increase
3. Soil conditions and Environment will improve and desertification will decrease
4. Resources will be better utilized
5. Soil salinity will decrease
6. More land will be brought under cultivation
7. Livestock will thrive so the farmer's income
8. Resource utilization will improve
9. Alternate use of drainage/storm water for growing crops and reduce water shortage
10. Productivity of degraded lands will improve
11. Irrigation water shortage will be supplemented
12. Support livestock by growing fodders on saline lands
13. Uplift the socio-economic conditions of the communities

8.10 Beneficial effects on the ecosystem of the area

1. Biological reclamation using plants tolerant to salinity and water logging to improve soil has been a major theme of research work in Pakistan.
2. Halophytes are plants that grow well in saline soil and water and compare well with forage crops like alfalfa. Halophytes may be used for a variety of purposes like food, fiber, fuel wood, medicines, source of chemicals, landscaping, ornamental, carbon sequestration, etc. One of the very important utilities lies in their use as fodder. An animal feeding trial showed that traditional green fodder (maize) and a halophytic grass *(Panicum)* were equally good for growth and development of 1-year-old cow calves. Meat from animals fed 100% *Panicum* was leaner and hence better for human consumption from health point of view (Ajmal and Raziuddin 2008).
3. Similarly dhancha (*sesbania aculeata*) possess good tolerance to salinity and sodicity with little tolerance to water logging. It is used as forage, firewood, dry sticks and green manuring and produces large amount of organic matter
4. Tree plantations lowered the water table in saline water logged areas. Based on 7 year study it was found that the water table became deeper an average of 5 cm under the tree canopy than that in barren lands. Surface level salts were considerably reduced in soils under tree canopies compared with bare fallow lands. When trees were raised with saline irrigation, the soil was enriched with organic carbon (>0.4%) in the upper 30 cm and there was no salinity build up in the profile.
5. Research in Sindh showed that salt affected soils and saline waters can be satisfactorily utilized in raising some forest and fruit trees, forage grasses, conventional and non-conventional crops, oil-yielding crops, aromatic and medicinal plants of high economic value, petro-crops and flower yielding plants using appropriate techniques.

Table 6: Yield of plant species in relation to the salinity (ECw) and (ECe)

Crop Species	100%		90%		75%		50%		0%		Salt Tolerance
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	
Barley	8.0	5.3	10	6.7	13	8.7	18	12	28	19	Tolerant
Cotton	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18	Tolerant
Sugarbeet	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16	Tolerant
Sorghum	6.8	4.5	7.4	5.0	8.4	5.6	9.9	6.7	13	8.7	Moderately Tolerant
Durum Wheat	5.7	3.8	7.6	5.0	10	6.9	13	8.7	20	13	Moderately Tolerant
Soybean	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7	Moderately Tolerant
Groundnut	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4	Moderately Sensitive
Rice	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6	Moderately Sensitive
Sugarcane	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12	Moderately Sensitive
Maize	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7	Moderately Sensitive
Flax	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7	Moderately Sensitive
Broad Bean	1.5	1.1	2.6	1.8	4.2	2.0	6.8	4.5	12	8.0	Moderately Sensitive
Green Bean	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2	Sensitive

Source: Katerje N.

8.11 Project period

The proposed project will be implemented in 5 years. The farmers shall be provided with the pumping sets, land clearing and development charges, channels, sub-channels and culverts costs will be paid to the farmers once in the first year of the project. After that the farmers shall pay for the maintenance and upkeep of the system by themselves. However, the capacity building by the NGOs and concerned government agencies shall provide technical knowhow for 5 year project tenure.

8.12 Project targets and phasing

Following are the tentative targets of the proposed project:

Total area of the marginal lands to be cultivated under bio-saline agriculture will be 50,000 Hectares.

Table 7: Area to be cultivated each year under Bio-saline Agriculture

Activity	Year-1	Year-II	Year-III	Year-IV	Year-V
Area under Bio-saline Agriculture (hectares)	4,047	4,047	4,047	4,047	4,047

8.13 Due Diligence & Technical activities

The main activities will include: i) survey of the marginal lands and water resources; ii) identification of potential sites for bio-saline agriculture; iii) Soil and water testing for establishing the conditions of soils and water resources; and iv) selection of suitable crop, grasses, fruit and or wood trees for specific soil and water conditions.

Table 8: Important Trees, Saltbushes, and Grasses Tolerant to Salinity and Water logging

Sr. No	*Botanical Name/Species*	Local Name	Tolerant to
Trees			
1.	*Eucalyptus camaldulensis*	Suphaida	Salinity and water logging
2.	*Eucalyptus rudis*	Suphaida	Salinity and water logging
3.	*Eucalyptus microtheca*	Suphaida	Salinity and water logging
4.	*Eucalyptus tereticornis*	Suphaida	Salinity and water logging
5.	*Tamarix aphylla*	Frash	Salinity
6.	*Terminala arjuna*	Arjan	Salinity and water logging
7.	*Salix Balulonica*	Baid	Salinity
8.	*Pogamia pinnata*	Sukhchain	Salinity
9.	*Acacia nilotica*	Kikar	Salinity and water logging
10.	*Acacia tortilis*	Kikar	Salinity and water logging
11.	*Acacia ampliceps*	Kikar	Salinity and water logging
12.	*Albizzia bebbeck*	Siris	Salinity
13.	*Eugenia jamolana*	Jaman	Salinity
14.	*Zizyphus jujuba*	Ber	Salinity
15.	*Pridium guajava*	Amrood	Salinity and water logging
16.	*Prosopis juliflora*	Jangli kikar	Salinity and water logging
17.	*Prosopis chilensis*	Jangli kikar	Salinity and water logging
18.	*Prosopis alba*	Jangli kikar	Salinity and water logging
19.	*Leucaena leucocephala*	Iple iple	Salinity
20.	*Salvadora oleoides*	Van	Salinity
21.	*Phoenix dactylifera*	Khajoor	Salinity and water logging
22.	*Prosopis spicegera*	Jand	Salinity
23.	*Capparis aphylla*	Karir	Salinity
24.	*Azadirachta indica*	Neem	Salinity
25.	*Suaeda fruticosa*	Lana	Salinity and sodicity

Sr. No	Botanical Name/Species	Local Name	Tolerant to
26.	*Grevia asiatica*	Falsa	Salinity
Salt bushes			
1.	*Suaeda fruticosa*	Lana	Salinity and sodicity
2.	*Salsola soda*	Sajj	Salinity and sodicity
3.	*Atriplex amnicola*	Saltbush	Salinity and water logging
4.	*Atriplex lentiformis*	Saltbush	Salinity and water logging
5.	*Atriplex undulata*	Saltbush	Salinity and sodicity
6.	*Maireana aphylla*	Blue Saltbush	Salinity and sodicity
7.	*Maireana amoona*	Blue Saltbush	Salinity and sodicity
8.	*Maireana pyramidata Grasses*	Blue Saltbush	Salinity and sodicity
9.	*Leptochloa fusc*	Kalar grass	Salinity and water logging
10.	*Sesbaania aculeate*	Jantar	Salinity
11.	*Penicum maximum*	Buffalo grass	Salinity and sodicity
12.	*Elitrigia elongata*	Tall wheat grass	Salinity
13.	*Setria italica*	Madhal	Salinity and Water logging
14.	*Panicum halbi*	Aalon	Salinity
15.	*Elinochloa crugallis*	Swank	Salinity
16.	*Penium miliaceum*	Swank	Salinity

Table 9: Salt Tolerance of Different Fodders
ECe of Soil (dS m^{-1}) Associated with 50% yield Reduction

Italian Rye-grass	11.20
Fodder Beet	19.00
Fodder Radish	11.00
Hawasi Radish	12.50
Lucerne Hijazi	12.20
Kallar-grass	22.00
Dhancha	13.00
Japani Millet	15.00

Source: Proceedings of Workshop/Seminar on Salt Tolerance in Plants UAF (1978)

Table 10: Income from biomass of different tree species on saline sodic soils after 11 years

Species	Timber production (kg plant^{-1})	Main stem length (m)	Gross return PKR y^{-1}
Leucaena leucocephala	90	7.32	6,000
Acacia nilotica	150	7.32	10,000
Parkinsonia aculeata	38	2.44	1,400
Albizzia lebbek	99	6.1	6,600
Eucalyptus camaldulensis	203	7.92	16,107
*Tamarix aphylla**	35	4.57	3,182
Prosopis cineraria	52	4.27	3,467
Total			46,756
Average			**6680**

Source: Aslam et al 2000.

Table 11: Salt Tolerance of Different Forage, Tree and Fruit Species

Echinochloa crusgalli (Japani millet)	Good tolerance to salinity and water logging grows as weed in rice crop, can be used as fodder.
Panicum maximum (Buffalo grass)	Good tolerance to salinity, tolerant to moderate drought, high palatability fodder beet high tolerance to salinity and sodicity, sensitive at germination.
Atriplex amnicola (Salt bush)	Very high tolerance to salinity/tolerant to drought, sensitive to water logging, easily propagated, palatability doubtful.
Elitrigia elongate (Tall wheat grass)	Good fodder with tolerance to salinity, growth rate is slow.
Sporobllus arabicus	Gives good growth in winter under saline condition.
Panicum turgidum (Tree species)	Good growth under saline conditions.
Eucalyptus camaldulensis (Suphaida)	Most of Eucalyptus species studied in Pakistan are reasonably tolerant to water logging and drought; high growth rate. Pakistan scientists suggest that this should not be planted on normal soils and fresh groundwater areas; rather it is suitable alternative for water table control in saline lands.
Lucaena leucocephala (Ipil Ipil)	Moderately tolerant to salinity and drought, sensitive to water logging, leaves make good fodder; rich in protein, can fix nitrogen.
Casurina eqeuistifolia	Tolerant to salinity and water logging, good ornamental and firewood value, can fix nitrogen; can be browsed by goats.
Tamarix aphylla (Frash)	Tolerant to salinity and water logging
Terminalia arjuna (Arjan)	Tolerant to salinity and water logging, good ornamental and firewood value and leaves used as fodder for goats.
Salix babilonica and Salix alba (Baid)	Tolerant to salinity and water logging.
Parkinsonia aculeate	Highly tolerant to salinity, good ornamental value and high biomass production.
Pogamia pinnata (Sukhchain)	Moderately tolerant to salinity and good ornamental value.
Albizzia lebbeck (Siris)	Moderately tolerant to salinity.

Acacia nilotica (Kikar)	High salt tolerance, relatively difficult to establish under saline condition, good firewood and browsing value and can fix nitrogen.
Fruit Species	
Eugenia Jambolana (Jaman)	High tolerance to salinity.
Zizphus jujube (Ber)	High tolerance to salinity.
Pridium guajava (Guava)	Moderately tolerant to salinity and water logging.
Grevia asiatica (Falsa)	High tolerant to salinity.

Source: Proceedings, First National Congress on Soil Science, Lahore, October 1985.

Table 12: Production cost and returns of various crops and trees in Kotri Barrage Command Area

(/ha)

Operation	Wheat	Paddy	Cotton	Sugarcane	Vegetables	Oil Seeds	Trees
Plowing	7299	10017	11070	4942	7687	5276	0
Seed	6748	2155	3015	39536	1707	230	1500
Sowing Labour	1240	3190	4547	3385	3788	519	600
FYM	0	0	0	0	0	0	0
Interculturing	0	0	1779	6548	7028	0	0
Fertilizer	24287	72	17999	9921	17603	3239	0
Irrigation	0	729	692	741	781	89	1000
Hired labour	0	3660			0	1334	600
Harvesting labour	3183	7060		24512	8787	1979	0
Pesticides etc	5	3837	12849	1853	0	0	0
Threshing	5715	0			0	0	0
Picking	0	0	11120		0	0	0
Total costs	**48477**	**30720**	**63071**	**91438**	**47381**	**12666**	**3700**
Yield (kg/ha)	2965	5436	3163	91000	31826	1087	
Value	65909						
Straw	3262					0	
Straw Value	6701					0	
Gross income	**72610**	**113713**	**289601**	**414634**	**89230**	**58489**	**2400000**
Net Return	**24133**	**82993**	**226530**	**323196**	**41849**	**45823**	**2396300**

8.14 Environmental effects /benefits

The proposed project is environment friendly on the following grounds:

- It will not have any adverse impacts on any green infrastructure of the areas.
- It will utilize the drainage water for growing trees and crops.
- It will improve degraded lands and increase their productivity.
- It will improve the physical and chemical structure of the degraded soils.
- There may be some salinity build up in the marginal soils but that too will be washed off due to monsoons rains in nearby drainage infrastructure.

8.15 Social benefits

The proposed project will have several socio-economic benefits for the society as under:

- Enhance productivity of lands in the form of food, wood, fodder and fuel.
- Provide livelihood opportunities to farm holders and associated workers through employment opportunities.
- Increase overall economy of the area by improving the productive capacity of degraded and unproductive lands.
- Livestock and wildlife will get improved grazing areas and habitats, respectively.
- Agricultural and livestock outputs will improve socio-economic status of farming community and associated stakeholders.
- The knowledge of use of drainage and storm water will transfer the technology from scientific community to rural agrarian society.
- Soil degradation will stop due to continuous cultivation of barren lands with crops, trees and grasses.

8.15.1 Cost of running the pump sets

Each pump set will require 1.25 liters of diesel per hour and shall deliver 3 cusecs of water. Each machine will deliver water to 200 acres.

1 cusec discharge requires 4 hours to fill one acre to a depth of 4 inches. Therefore 3 cusec discharge will require 1.3 hours to fill one acre. The cost of diesel is Rs. 100/- per liter. The cost of diesel to fill one acre to a depth of 4" would require 1.3x1.25 = 1.7 liters of diesel. Thus the cost of diesel will be Rs. 170/- . Taking an average of five irrigations the total cost of diesel would be Rs. 850/- per acre. The repair and maintenance cost is assumed as 10% to 15% of the purchase price. The purchase price of machine is Rs.50, 000; therefore the repair and maintenance costs would be Rs. 162.50 per crop per acre. The total cost of machinery including fuel and repair will be just Rs. 1000 per acre.

8.16 Earning from Crops and Trees

Considering the cost of seed, fertilizer and pesticide per acre equal to Rs. 5000/ acre. The return from the land in growing rice crop would be in the range of Rs.10000 to 50,000. As such the farmer will earn substantial income from his marginal land. The income from crops would be much higher as these will be seasonal and would be supportive to the farmers.

In growing trees, if the space between plant to plant is considered as 10 ft, there will be 500 plants in an acre. Therefore, total income from an acre would be in the range from Rs. 35,000 to 50,000.

8.16.1 Investment and Financing Plans

The total estimated cost of the project is Rs.1038 million. The estimates of costs are based on existing rates being used in the development projects in coastal areas of Sindh. The preliminary year wise cost estimates and detailed breakups are presented in Table-13.

Efforts will be made to solicit funding support from international donors and development partners. The project aim is multidimensional having positive impacts on overall environment of the region, support of the communities in enhancing their livelihood opportunities and increase in agriculture produce with support for the livestock.

8.16.2 Implementation Arrangements

The project will be implemented by the project management in close coordination with stakeholders and farmers of the area. The NGO will be responsible for motivating the farmers and arranging the trainings for farmers together with capacity building of the stakeholders. All project activities will be arranged in close association with stakeholders.

8.16.3 Time Frame

The implementation period for the proposed intervention is five years.

8.16.4 Executing and Implementing Agencies

The executing agency will be Forest Department Government of Sindh for implementation of the project intervention. The project will be implemented through community based participatory approach. On privately owned lands, the Forest Department will be responsible for all operational and management aspects, under public-private-partnership arrangements. NGOs will arrange the capacity building tasks to motivate and train the local community stakeholders to participate and benefit from the intervention. All the technical support will be provided by the project staff including the selection of the crops, grasses, fruit and other trees keeping in view the condition of the land and the quality of the available water resource. In addition the project staff will also inform the stakeholders about the impact of using the marginal quality water on their lands and crop yields.

The experience so far gained reveals that due to ecological, environmental, social and economic importance the project will be supportive for the communities and overall environment of the region. The implementation of the project is proposed to be participatory including government department, NGOs and local communities.

8.17 Site identification and selection

Site selection is an important step for this intervention. The exact areas to be planted under various crop, grasses and trees will be identified through field visits / surveys, consultations with stakeholders and by observing technical details. It is estimated that about 20,235 hectares will be brought under bio-saline agriculture selecting suitable crops or trees and grasses in the coastal areas of Badin and Thatta districts.

8.18 Monitory benefits from the intervention

The intervention will generate significant quantifiable and non quantifiable benefits. A preliminary assessment of the anticipated benefits is presented in with and without intervention analytical framework.

The preliminary indicative rate of return of the intervention (IERR) is 15.5%. The details of cost analysis are given in Tables 13 and 14.

8.19 Non Quantifiable Benefits

The environment of the area will be improved. The land degradation process will minimize. Wherever, there is likelihood of increase in soil salinity, efforts will be made to rectify by draining the accumulated rain water in monsoon season to wash away the salts into the nearby drainage structures. The livestock will be reared on the grasses and forage thus benefiting the stakeholders.

The proposed project will have positive impacts on the social aspects of the society such as poverty, income distribution, employment generation, livelihood opportunities, and gender mainstreaming. With the development of this project and its execution through integrated and participatory approaches the coastal people will be mobilized, organized and act as executing team will get direct and indirect employment and sources of livelihood which will ultimately alleviate poverty and distribute benefits equitably. Due to participatory approach the local communities will be involved from initial stages of project development, survey, selection of sites, land development, and water distribution system installation activities. Furthermore, the communities will own the project. Women will also be involved in all the processes of the project.

8.20 Monitoring and Evaluation Mechanism

The purpose of monitoring and evaluation will be to provide timely feedback and analysis to the program partners for making management decisions. This information will be used to facilitate problem-solving at the local level; identify trends requiring corrective actions, evaluate program performance, undertake impact assessment, and to document successful approaches and lessons learned and support strategic planning efforts. Monitoring indicators will be as under:

1. Total number of acres planted under crops grasses fruit and other trees and the livestock reared.
2. Anticipated yields and yields obtained from various interventions
3. The resources (Land and water) were beneficially utilized or under-utilized
4. The overall project benefits
5. The increase in the farmers income
6. Increase in the environmental outlook
7. Satisfaction of the stakeholders
8. Cost-benefit analysis on year basis

8.21 Monitoring roles and responsibilities

It is essential to define the roles and responsibilities of monitoring and evaluation of participatory M & E. Since the process of project identification and preparation has been participatory in which all the stakeholders have been involved, the monitoring shall also have to be participatory. The tools described above for participatory monitoring also describes the roles and responsibilities for monitoring and review of the plan. In addition, committees comprising of the project management, NGOs and stakeholders should be formulated for monitoring of the project.

8.22 Review process of Participatory Approach

Like monitoring, the review process shall have to be participatory involving representatives of all stakeholders. The success of Project will be judged from the achievements of indicators set during investigation exercises of project. Communities taking the responsibilities of participatory management in collaboration and participation of other stakeholders shall also set review process. Review process shall be continuous, critical and result oriented. Initially the project area shall be reviewed frequently and the corrective measures taken accordingly but the period of review could be increased as the participating actors gain experience and expertise of participatory management.

8.23 Environmental Impact

The proposed project will not create any environmental issue in the project area but will address the existing environmental issues pertaining to land degradation, soil and water quality, productivity of lands, soil and water pollution and overall environment of the area. The project shall also have positive impact on overall livelihood opportunities in the area.

8.24 Re-settlement Issues

The proposed project will not warrant any resettlement issue.

8.25 Economic Analysis

The estimated IERR has been computed at 15.5 %, hence the project is economically viable. The NPV at 12% is Rs.118.3 million. The sensitivity analysis presented in the table-13 shows that with 10% decrease in the benefits the IERR is 13.5 % while with 10% increase in the cost the IERR is about 13.6%. Both of these are above 12%. The simultaneous 10% decrease in benefits and increase in cost suggests the IERR is 11.8% and is below12%, hence it is moderately sensitive.

The switching value indicate that if the benefits decrease by 17.2%, and costs increase by 20.5%, while even if both may change by 9.1% the project will not be viable.

Table 13: IERR and Sensitivity Analysis

#	Scenario	NPV @12%	IERR	Switching Value
1	Base Case	118.3	15.5%	
2	Decrease in Benefits (10%)		13.5%	17.2%
3	Increase in Costs (10%)		13.6%	20.5%
4	Simultaneous Change by 10%		11.8%	9.1%

8.26 Sources of funding

The government of Sindh with the assistance of the federal government will tap foreign donors to finance this project. The proposed project is a pilot project to be executed through a participatory approach by involving interested stakeholders specially the landowners whose agricultural lands have been degraded due to the lands lying barren for years, but still there is potential to enhance their productivity by changing land use according to the availability and use of water for such land use. The land owners in the vicinity shall make *warabandi* of their own to share the drain water for cultivating their lands on rational basis amicably.

8.27 Project Limitations

It is intended to use the drain water for the proposed intervention. At present, Karo Ghungro and Guni Phuleli drains carry sugar mills effluent including effluent from distilleries. Similarly, the drainage effluent flowing in KPOD also carries with it sufficient quantities of sugar mill effluents being drained into the drainage infrastructure from various sugar mills. This effluent is highly polluted with organic materials that heavily consume the oxygen present in drain water resulting in depletion of oxygen that may cause death of fish and other living creatures using this water. This water is equally hazardous for the crops, trees, grasses to be grown under this intervention. It is therefore extremely important that before going to implement this project, it may be ensured that the sugar mill effluents are stopped entering into these drains. EPA Sindh should invoke the relevant legislation regarding prohibition of disposing the industrial effluents into water bodies and must enforce the EPA act to stop this illegal practice in vogue.

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Table 14: Detailed Quantities of Bio-saline Agriculture in Badin and Thatta Districts

	Quantities							
	Unit	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs								
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures								
Double Cab Pickup	#	1	-	-	-	-	-	1
Single Cab Pickup	#	1	-	-	-	-	-	1
Pump Sets	#	125	125	125	125	125	-	625
Office equipment /a	ls							
Office Furniture & Fixtures	#	1	-	-	-	-	-	1
Subtotal								
B. Survey & Investigations								
Survey and Mapping	ls							
C. Civil Works								
Office Block /b	ls							
Drainage Water Distribution System /c	acres	10,000	10,000	10,000	10,000	10,000	-	50,000
Subtotal								
D. Plantation Cost								
1. Salt Tolerant Tree Planting	acres	-	1,500	1,500	1,500	500	-	5,000
E. Capacity Building								
Farmer Training Cost	ls							
F. Consultancies, Studies, and Services								
1. Capacity Building NGOs	ls							
2. Soil Water Testing Services	ls	10,000	10,000	10,000	10,000	10,000	-	50,000
Subtotal								
G. Operations Cost								
1. Project Staff Cost								
Project Manager	pm	12	12	12	12	12	-	60
Assistant Project Manager	2 pm	12	12	12	12	12	-	60
Superintendent	pm	12	12	12	12	12	-	60
Accountant	pm	12	12	12	12	12	-	60
Computer Operator	2 pm	12	12	12	12	12	-	60
Office Assistant	4 pm	12	12	12	12	12	-	60
Field Assistants	10 pm	12	12	12	12	12	-	60
Vehicle Drivers	2 pm	12	12	12	12	12	-	60
Chowkidar	10 pm	12	12	12	12	12	-	60
Beldars	10 pm	12	12	12	12	12	-	60
Labor	50 pm	12	12	12	12	12	-	60
Subtotal								
2. Travel Cost (TA/DA)	ls							
3. Vehicle Operating Cost	per year	2	2	2	2	2	-	10
4. Expendables & Utilities	ls							
Subtotal								
Total Investment Costs								
II. Recurrent Costs								

Table 15: Detailed Base Costs of Bio-saline Agriculture in Badin and Thatta Districts

	Unit Cost (PRs)	Base Cost (PRs Million)						
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs								
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures								
Double Cab Pickup	2,700,000	2.7	-	-	-	-	-	2.7
Single Cab Pickup	2,000,000	2.0	-	-	-	-	-	2.0
Pump Sets	50,000	6.3	6.3	6.3	6.3	6.3	-	31.3
Office equipment /a		2.0	-	-	-	-	-	2.0
Office Furniture & Fixtures	1,000,000	1.0	-	-	-	-	-	1.0
Subtotal		14.0	6.3	6.3	6.3	6.3	-	39.0
B. Survey & Investigations								
Survey and Mapping		2.0	2.0	1.0	-	-	-	5.0
C. Civil Works								
Office Block /b		2.5	-	-	-	-	-	2.5
Drainage Water Distribution System /c	10,000	100.0	100.0	100.0	100.0	100.0	-	500.0
Subtotal		102.5	100.0	100.0	100.0	100.0	-	502.5
D. Plantation Cost								
1. Salt Tolerant Tree Planting	14,000	-	21.0	21.0	21.0	7.0	-	70.0
E. Capacity Building								
Farmer Training Cost		1.0	3.5	4.0	3.0	2.0	-	13.5
F. Consultancies, Studies, and Services								
1. Capacity Building NGOs		5.0	5.0	5.0	5.0	5.0	-	25.0
2. Soil Water Testing Services	5,000	50.0	50.0	50.0	50.0	50.0	-	250.0
Subtotal		55.0	55.0	55.0	55.0	55.0	-	275.0
G. Operations Cost								
1. Project Staff Cost								
Project Manager	150,000	1.8	1.8	1.8	1.8	1.8	-	9.0
Assistant Project Manager	75,000/pm	1.8	1.8	1.8	1.8	1.8	-	9.0
Superintendent	35,000	0.4	0.4	0.4	0.4	0.4	-	2.1
Accountant	25,000	0.3	0.3	0.3	0.3	0.3	-	1.5
Computer Operator	20,000/pm	0.5	0.5	0.5	0.5	0.5	-	2.4
Office Assistant	20,000/pm	1.0	1.0	1.0	1.0	1.0	-	4.8
Field Assistants	20,000/pm	2.4	2.4	2.4	2.4	2.4	-	12.0
Vehicle Drivers	15,000/pm	0.4	0.4	0.4	0.4	0.4	-	1.8
Chowkidar	15,000/pm	1.8	1.8	1.8	1.8	1.8	-	9.0
Beldars	15,000/pm	1.8	1.8	1.8	1.8	1.8	-	9.0
Labor	15,000/pm	9.0	9.0	9.0	9.0	9.0	-	45.0
Subtotal		21.1	21.1	21.1	21.1	21.1	-	105.6
2. Travel Cost (TA/DA)		0.1	0.1	0.1	0.1	0.1	-	0.5
3. Vehicle Operating Cost	240,000	0.5	0.5	0.5	0.5	0.5	-	2.4
4. Expendables & Utilities		0.3	0.3	0.3	0.3	0.3	-	1.5
Subtotal		22.0	22.0	22.0	22.0	22.0	-	110.0
Total Investment Costs		196.5	209.8	209.3	207.3	192.3	-	1,015.0
II. Recurrent Costs								
		196.5	209.8	209.3	207.3	192.3	-	1,015.0

Table 16: Detailed Contingency Costs of Bio-saline Agriculture in Badin and Thatta Districts

	Totals Including Contingencies (PRs Million)						
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
I. Investment Costs							
A. Machinery, Equipment, Vehicles, and Office furniture & Fixtures							
Double Cab Pickup	2.9	-	-	-	-	-	2.9
Single Cab Pickup	2.1	-	-	-	-	-	2.1
Pump Sets	6.7	6.9	7.2	7.4	7.7	-	35.9
Office equipment /a	2.1	-	-	-	-	-	2.1
Office Furniture & Fixtures	1.1	-	-	-	-	-	1.1
Subtotal	15.0	6.9	7.2	7.4	7.7	-	44.2
B. Survey & Investigations							
Survey and Mapping	2.3	2.5	1.3	-	-	-	6.1
C. Civil Works							
Office Block /b	2.9	-	-	-	-	-	2.9
Drainage Water Distribution System /c	117.0	122.8	129.0	135.4	142.2	-	646.3
Subtotal	119.9	122.8	129.0	135.4	142.2	-	649.2
D. Plantation Cost							
1. Salt Tolerant Tree Planting	-	25.8	27.1	28.4	10.0	-	91.3
E. Capacity Building							
Farmer Training Cost	1.2	4.3	5.2	4.1	2.8	-	17.5
F. Consultancies, Studies, and Services							
1. Capacity Building NGOs	5.8	6.1	6.4	6.8	7.1	-	32.3
2. Soil Water Testing Services	58.5	61.4	64.5	67.7	71.1	-	323.1
Subtotal	64.3	67.5	70.9	74.5	78.2	-	355.5
G. Opeartions Cost							
1. Project Staff Cost							
Project Manager	1.9	2.0	2.1	2.1	2.2	-	10.3
Assistant Project Manager	1.9	2.0	2.1	2.1	2.2	-	10.3
Suprintendent	0.5	0.5	0.5	0.5	0.5	-	2.4
Accountant	0.3	0.3	0.3	0.4	0.4	-	1.7
Computer Operator	0.5	0.5	0.5	0.6	0.6	-	2.7
Office Assistant	1.0	1.1	1.1	1.1	1.2	-	5.5
Field Assistants	2.6	2.7	2.7	2.8	2.9	-	13.7
Vehicle Drivers	0.4	0.4	0.4	0.4	0.4	-	2.1
Chowkidar	1.9	2.0	2.1	2.1	2.2	-	10.3
Beldars	1.9	2.0	2.1	2.1	2.2	-	10.3
Labor	9.7	10.0	10.3	10.6	10.9	-	51.5
Subtotal	22.7	23.4	24.1	24.9	25.6	-	120.7
2. Travel Cost (TA/DA)	0.1	0.1	0.1	0.1	0.1	-	0.6
3. Vehicle Operating Cost	0.5	0.5	0.6	0.6	0.6	-	2.8
4. Expendables & Utilities	0.3	0.3	0.4	0.4	0.4	-	1.8
Subtotal	23.7	24.4	25.2	25.9	26.7	-	126.0
Total Investment Costs	226.5	254.3	265.7	275.7	267.5	-	1,289.7
II. Recurrent Costs							
	226.5	254.3	265.7	275.7	267.5	-	1,289.7

Table 17: Economic Analysis for Bio-saline Agriculture in Badin and Thatta Districts

A	**Without Project**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**15**	**20**
A-1	Area in Acre	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A-2	Net Income per Acre (Rs.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A-3	Value of Output (Rs. Mi)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B	**With Project**												
B-1	Area in Acre	-	10,000	20,000	30,000	40,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
B-3	Value of Output (Rs. Mi)	0.0	27.0	54.0	81.0	108.0	135.0	135.0	135.0	135.0	135.0	135.0	135.0
C	Incremental Benefits (Rs. M)	0.00	27.00	54.00	81.00	108.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
D	Cost of Intervention (Rs M)	154.70	164.90	164.50	162.90	151.40							
E	Incremental Cash Flow (Rs. M)	-154.7	-137.9	-110.5	-81.9	-43.4	135.0	135.0	135.0	135.0	135.0	135.0	135.0
F	NPV @ 12% (Rs. M)	118.3											
G	IERR	15.5%											